KNOWLEDGE
AN ILLUSTRATED
MAGAZINE OF SCIENCE
PLAINLY WORDED—EXACTLY DESCRIBED

LONDON: FRIDAY, AUG. 17, 1883.

CONTENTS OF No. 94.

	PAGE
A Naturalist's Year. A Rabbit's Skull. By Grant Allen	97
The Chemistry of Cookery. XVI. By W. Mattieu Williams	98
How to Get Strong	99
Pretty Proofs of the Earth's Rotundity. (*Illus.*). By R. A. Proctor	100
The Amateur Electrician. Batteries. III.	102
Pleasant Hours with the Microscope. (*Illus.*) By H. J. Slack	103
The Shoebill (*Illustrated*)	105
The Morality of Happiness: Evolution of Conduct. By T. Foster	105
Laws of Brightness. VIII. By R. A. Proctor	106
The Death of Captain Webb	108
The Face of the Sky	109
Correspondence	109
Our Mathematical Column: Geometrical Problems. XII.	111
Our Chess Column	112

A NATURALIST'S YEAR.

By GRANT ALLEN.

XIX.—A RABBIT'S SKULL.

WALKING this sunny August morning on the breezy saddle of the great chalk down, where the combes on either side are thickly overgrown with low scrub of stunted juniper bushes, at each step I take I see the twinkling white tails and tall ears of the pretty brown rabbits disappearing into their trusty burrows hidden cosily beneath the spreading bracken and the tangled gorse-runs. Poor timid wee things, how nervously they hurry and scurry away across the open patches, at the first sound of that dull thud which heralds to their watchful senses the approach of their heriditary foe, man, the possible hunter and probable gun-bearer! It shames me for my kind when I think that they took no heed at all of yonder philosophic old donkey, browzing quietly off the stemless thistles and dry carline on the windy hill-side, nor of the burly bell-wether himself who leads the flock of ruddled sheep in the deep hollow by the old yew-tree; but the moment they heard the distant rustle of my foot-fall upon the dry stems of bramble and bracken, they lifted the danger-signal of their white tails forthwith to their young ones among the fresh furze-brake, and darted off to their holes in dismay, as from the dreaded presence of a familiar enemy. It has come to this, then, that we men have waged needless war of extermination upon all these pretty wild creatures till they have learnt to condemn us all under a single category—*omnes uno ordine Achivos*—and to shrink instinctively even from those among us who would best appreciate their sympathy and their confidence. It must e'en be so, though even now much may be done, with care and patience, in the way of establishing friendly personal relations with these, our timid fellow-denizens of the soil of Britain. I will sit quiet awhile on the edge of the disused chalk-pit here till they have forgotten my sudden irruption, and by-and-by I shall no doubt be rewarded by seeing them peep cautiously out from the mouths of their burrows, with eyes and ears alert for every symptom of danger, till at last they begin to disregard my presence, and gambol freely on the open greensward before the very face of their once-suspected but now unheeded visitor.

See, here on the side of the pit is a dry, blanched skull, the sole remaining memento of some lost and nameless and forgotten bunny. Was he wounded by a casual gunshot, and left upon the ground undiscovered, I wonder; or was he hawked at and devoured at leisure by some vigilant night-prowling owl; or was he caught on the open, and miserably sucked to death by the sharp teeth of some cruel weasel? None of these, I can see at a glance; it was Nature itself that failed my poor rabbit; he died from sheer mal-adaptation to his own ingrained racial requirements. Look closely at his lower jaw, and you will observe that the great gnawing teeth—the incisors from which the rodent group takes its scientific name—have grown out into an immense arch, until they have doubled in again upon themselves, and at last caused the death of their unhappy owner by starvation. I have seen rabbits' teeth in this same condition before, and the reason for it is easy enough to understand. The big incisors of rodents have no roots, but spring from a permanent pulp, so that they continue growing uninterruptedly throughout the entire life of the animal. This arrangement has naturally been brought about by survival of the fittest, because the rodents have to pass their days in a perpetual round of gnawing, and they can't even be happy without something or other hard on which to exercise their teeth, as everybody has observed in the case of tame squirrels. But in order to prevent the teeth from getting entirely worn away by such continual use, it is necessary that they should keep on always growing from below, to make up for the unceasing waste above. Now, in the dead rabbit before us, the two jaws were placed at a slightly irregular angle—too much underhung, as the dentists call it in the human species—and therefore the teeth did not meet, as they ought to do, and get worn off at the end by attrition against one another. The consequence has been that the incisors have bent round into a perfect semi-circle, and so killed the rabbit by preventing him from opening or shutting his jaws properly.

Even in the normal state the teeth of hares and rabbits are very interesting from their evolutionary implications. This small group of rodents preserves for us, to some slight extent, an early intermediate stage between the original central mammalian stock and the thorough-going modern rodents. If you look at the skull of a squirrel or a mouse, or any other typical rodent, you will find that it has only two kinds of teeth, incisors and molars, without any canines; and also that the incisors number two only in each jaw. This is clearly a great reduction of the primitive pattern, and it is accompanied by a great gap between the large specialised incisors and the far smaller but still somewhat peculiar molars. But if you examine the upper jaw of a hare or a rabbit, you will find that it contains, besides the big pair of working incisors, a small rudimentary pair, immediately behind them, and quite useless for any practical purpose. They are, in fact, a survival from the time when the ancestors of the rodents had at least four working incisors in each jaw; and they mark out the hares and rabbits as being an earlier, more primitive branch of the rodent type than the two-incisored rodents, like the squirrels, rats, and beavers. I say at least four incisors, because we have good reason to suppose that there were once six; indeed, the young hare has still six in the upper jaw at birth, but two of them fall out while he is still a mere baby. This reappearance of ancestral peculiarities in very young animals is, we know, one of the greatest aids to the reconstruction of lost or doubtful pedigrees.

Fossil forms, again, often help us to piece out the scanty evidence thus afforded us by living species; and one good bit of evidence in this direction is forthcoming even for

the genealogy of so isolated and divergent a group as the rodents. South America is a perfect mine of antiquated types, living or extinct; its long separation from the rest of the world, before the restoration of communications *viâ* the Isthmus of Panama, made it a sort of rival to Australia and the Cape of Good Hope as an area for the preservation of early forms, superseded elsewhere by the higher modifications which result from the fiercer competition and harder struggle for life in the great continents. In the pliocene deposits of La Plata, accordingly, there occur the bones of a singular early creature, a missing link in the way of a rodent, which helps to bridge over the gap to the main line of mammalian development. This most primitive known type of rodent (most primitive in organisation, I mean, for we have true squirrels and other perfect rodents much earlier in time) is known as *Mesotherium* (or Intermediate Beast), and has four incisors in its lower jaw. The second pair are smaller than the first, and are placed behind them; and in some other dental peculiarities this stranded type more nearly approaches the ordinary central form of mammals. In particular, the great incisors themselves are blunter and far less characteristically rodent-like than in all the existing species. Now, it is quite clear that the *raison d'être* of the rodents as a group, the fundamental difference upon which all their other class-differences depend, is the peculiar nature of their teeth; so that in this isolated South American form we have, so to speak, a central mammalian type in the very act of growing into a true rodent. In many ways Mesotherium recalls the hoofed animals, and especially that aberrant little Syrian creature, the so-called coney, the last survivor of an order now otherwise quite extinct. There are other points in which it resembles those other archaic South American mammals, the sloths and armadillos; and altogether we may consider it as a late lingering form of a very primitive rodent type, preserved in the once insular Neotropical region long after all its kind had been lived down elsewhere by the more advanced and perfected true rodents. Thus, we may fairly conclude that the ancestors of squirrels and rabbits probably started from a type hardly superior in organisation to the Australian marsupials, and linked on either hand to the hoofed animals and to the edentates; that they gradually lost the two useless incisors in either jaw, except in the case of the hare and rabbit section, which still retains one pair in a rudimentary condition; and that at the same time they gradually modified the remaining and functional pair in adaptation to their special habits, till at last they grew into the very long and efficient, sharp, cutting tools with whose appearance we are so familiar in the case of the rabbit, the mouse, and the squirrel.

THE CHEMISTRY OF COOKERY.

XV.

By W. Mattieu Williams.

A CORRESPONDENT of Manchester asks me which is the most nutritious, a slice of English beef in its own gravy, or the browned morsel as served in an Italian restaurant with the burnt sugar addition to the gravy?

This is a very fair question and not difficult to answer. If both are equally cooked, neither over-done nor under-done, they must contain weight for weight exactly the same constituents in equally digestible form, so far as chemical composition is concerned. Whether they will actually be digested with equal facility and assimilated with equal completeness depends upon something else not measurable by chemical analysis, viz., the relish with which they are respectively eaten. To some persons the undisguised fleshiness of the English slice, especially if underdone, is very repugnant. To these the corresponding morsel, cooked according to Francatelli rather than Mrs. Beeton, would be more nutritious. To the carnivorous John Bull, who regards such dishes as "nasty French messes," of questionable composition, the slice of unmistakable ox flesh, from a visible joint, would obtain all the advantages of appreciative mastication and that sympathy between the brain and the stomach, which is so powerful, that when discordantly exerted may produce the effects that are recorded in the case of the sporting traveller, who was invited by a Red Indian chief to a "dog-fight," and ate with relish the savoury dishes at what he supposed to be a preliminary banquet. Digestion was tranquilly and healthfully proceeding, under the soothing influence of the calumet, when he asked the chief when the fight would commence. On being told that it was over, and that in the final *ragout* he had praised so highly the last puppy-dog possessed by the tribe had been cooked in his honour, the normal course of digestion of the honoured guest was completely reversed.

Reverting to the fat used in frying, and the necessity of its purification, I may illustrate the principle on which it should be conducted by describing the method adopted in the refining of mineral oils, such as petroleum or the paraffin distillates of bituminous shales. These are dark, tarry liquids of treacle-like consistency, with a strong and offensive odour. Nevertheless they are, at but little cost, converted into the "crystal oil" used for lamps, and that beautiful pearly substance, the solid, translucent paraffin now so largely used in the manufacture of candles. Besides these, we obtain from the same dirty source an intermediate substance, the well-known "*Vaseline*," now becoming the basis of most of the ointments of the pharmacopœia. This purification is effected by agitation with sulphuric acid, which partly carbonises and partly combines with the impurities, and separates them in the form of a foul and acrid black mess, known technically as "acid tar." When I was engaged in the distillation of cannel and shale in Flintshire, this acid tar was a terrible bugbear. It found its way mysteriously into the Alyn river, and poisoned the trout; but now, if I am correctly informed, the Scotch manufacturers have turned it to profitable account.

Animal fat and vegetable oils are similarly purified. Very objectionable refuse fat of various kinds is thus made into tallow, or material for the soap-maker, and grease for lubricating machinery. Unsavoury stories have been told about the manufacture of butter from Thames mud or the nodules of fat that are gathered therefrom by the mudlarks, but they are all false. It may be possible to purify fatty matter from the foulest of admixtures, and do this so completely as to produce a soft, tasteless fat, *i.e.*, a butter substitute, but such a curiosity would cost more than half-a-crown per pound, and therefore the market is safe, especially as the degree of purification required for soap-making and machinery grease costs but little, and the demand for such fat is very great.

These methods of purification are not available in the kitchen, as oil of vitriol is a vicious compound. During the siege of Paris some of the Academicians devoted themselves very earnestly to the subject of the purification of fat in order to produce what they termed "siege butter" from the refuse of slaughter-houses, &c., and edible salad oils from crude colza oil, the rancid fish oils used by the leather-dresser, &c. Those who are specially interested in the subject may find some curious papers in the *Comptes*

Rendus of that period. In Vol. 71, page 36, M. Boillot describes his method of mixing kitchen-stuff and other refuse fat with lime-water, agitating the mixture when heated, and then neutralising with an acid. The product thus obtained is described as admirably adapted for culinary operations, and the method is applicable to the purpose here under consideration.

Further on in the same volume is a "Note on Suets and Alimentary Fats" by M. Dubrunfaut, who tells us that the most tainted of alimentary fats and rancid oils may be deprived of their bad odours by "appropriate frying." His method is to raise the temperature of the fat to 140° to 150° Centigrade (284° to 302° Fahr.) in a frying-pan; then cautiously sprinkle upon it small quantities of water. The steam carries off the volatile fatty acids producing the rancidity in such as fish-oils, and also the neutral offensive fatty matters that are decomposed by the heat. In another paper by M. Fua this method is applied to the removal of cellular tissue of crude fats from slaughter-houses. It is really nothing more than the old farm-house proceeding of "rendering" lard, by frying the membranous fat until the membranous matter is browned and aggregated into small nodules, which constitute the "scratchings"—a delicacy greatly relished by our British ploughboys at pig-killing time, but rather too rich in pork fat to supply a suitable meal for people of sedentary vocations.

The action of heat thus applied and long-continued is similar to that of the strong sulphuric acid. The impurities of the fat are organic matters more easily decomposible than the fat itself, or otherwise stated, they are dissociated into carbon and water at about 300° Fahr., which is a lower temperature than that required for the dissociation of the pure oil or fat (see No. 13 of this series, July 6th). By maintaining this temperature, these compounds become first caramelised, then carbonised nearly to blackness, and all their powers of offensiveness vanish, as such offence is due to slow decomposition of the original organic compounds, which now exist no longer, and the remaining caramel or carbon cinders being quite inoffensive or no further decomposible by atmospheric agency.

In the more violent factory process of purification by sulphuric acid the similar action which occurs is due to the powerful affinity of this acid for water; this may be strikingly shown by adding to thick syrup or pounded sugar about its own bulk of oil of vitriol, when a marvellous commotion occurs, and a magnified black cinder is produced by the separation of the water from the sugar.

The following simple practical formula may be reduced from these data. When a considerable quantity of much-used frying fat is accumulated, heat it to about 300° F., as indicated by the crackling of water when sprinkled on it, or, better still, by a properly constructed kitchen thermometer* graduated to about 400° F. Then pour the melted fat on hot water. This must be done carefully, as a large quantity of fat at 400° poured upon a small quantity of boiling water will illustrate the fact that water when suddenly heated is an explosive compound. The quantity of water should exceed that of the fat, and the pouring be done gradually. Then agitate the fat and water together, and, if the operator is sufficiently skilful and intelligent, the purification may be carried further by carefully boiling the water under the fat, and allowing its steam to pass through; but this is a little dangerous, on account of the possibility of what the practical chemist calls "bumping," or the sudden formation of a big bubble of steam that would kick a good deal of the superabundant fat into the fire.

Whether this supplementary boiling is carried out or not, the fat and the water should be left together to cool gradually, when a dark layer of carbonised impurities will be found resting on the surface of the water, and adhering to the bottom of the cake of fat. This may be peeled off and put into the waste grease-pot, to be further refined with the next operation. Ultimately the worst of it will sink to the bottom of the water. Then it is of no further value, and will be found to be a mere cinder.

* I have a vague impression of having seen such an instrument advertised, but cannot remember where, or by what maker. It may be worth his while to benefit the readers of KNOWLEDGE, and himself, by re-advertising therein, with particulars of price, &c.

HOW TO GET STRONG.

REDUCING FAT.

I HAVE received through the editor several letters relating to preparations—some patent medicines others offered in the form of prescriptions—for reducing fat without change of regimen or increase in the amount of exercise taken daily. Of all these preparations it is to be observed that they are advertised solely to make money. In every single case which has thus far been brought under my notice, the unfortunate heavy weight is invited to spend a large sum of money in the purchase of many bottles of some preparation in order that he may after many weeks find his weight notably reduced. Either the medicine is offered without any account of its ingredients, or in reply to letters the advertiser gives a prescription such as no chemist would be likely to mix, and such as the advertiser asserts that few chemists can mix properly even if willing. In one case, the corpulent are told in so many words that a number of bottles of the medicine are to be bought and consumed before any good effects will begin to be recognised. In the other the advertiser seems to offer a prescription gratis; but it comes really to the same thing; he knows that the persons who answer his advertisement will apply to him for the medicine, and in the cases which have come under my notice he asks a monstrous price for a preparation probably quite worthless and possibly (when used as recommended in large quantities) most mischievous. As to the value of any medicine for reducing fat, it should be noticed that only a long course of experiments conducted on a great number of persons, and under very various conditions, could possibly prove that a preparation was a specific against obesity,—and certainly no such experiments have been made in the case of any of the advertised medicines. If there were any medicine by which fat could certainly be diminished in a few weeks or months, it is *almost certain* that the constitution would be injured far more seriously by the medicine than it had been by obesity; and whereas undue fat can be removed by patient perseverance in health-giving regimen, the mischief done to the constitution by the long-continued use of nostrums for reducing fat would probably be permanent. Unquestionably it is most unwise for persons troubled with obesity to use any nostrum without medical advice; and I believe no medical man would advise the use of any one of the advertised cures for obesity.

I return to the various measures which a sensible person anxious to reduce fat without impairing the general health may use with advantage.

We come now to the measures by which the healthy action of the skin may be encouraged, and so fat reduced through increased perspiration. Exercise of course encourages perspiration, but I am for the moment speaking

XUM

not of exercise but of direct stimulation of the sudatory action.

First, the question may be asked whether Turkish baths, vapour baths, hydropathic treatment, and so forth, tend to reduce fat.

We may take the Turkish bath as a typical process for directly reducing weight by increased perspiration. Many have taken Turkish baths with the idea of diminishing their weight, and have been disappointed. I believe that those who most warmly advocate the use of the hot air baths, including those who are commercially interested in establishments where these baths can be taken, claim no fat-reducing effect from them. It is certain, as I know from my own experience, that you may take a Turkish bath five or six times in a week, and for several weeks in succession, without appreciably affecting the weight. Two or three pounds may be lost in the hot rooms, but then two or three pounds will be added to the weight through increased drinking during the next few hours.

Yet Turkish baths may be effectively used for the special purpose of reducing weight, if we remember that we are not to trust to the loss of weight by increased perspiration in the hot rooms, but to the improved condition of the skin. I have taken as many as twenty Turkish baths in a month without loss of weight, though probably some forty pounds' weight may have been actually parted with in the hot rooms; and I have lost as much as fifteen pounds of weight in ten days, indirectly through the action of five or six hot-air baths. This sounds paradoxical; but it is strictly true. In one case, I had been ill, and I took so many Turkish baths, as an easy way of keeping the skin in a healthy state when I was unable to take much exercise. In the other case, I wanted to reduce weight, and I took much exercise, especially just after each hot-air bath. The same amount of exercise by which one would lose a pound's weight under average conditions will remove two or three pounds' weight after a Turkish bath. Thus hot-air baths used as subsidiary to active exercise, are effective fat reducers,—used as a substitute for active exercise they do not reduce fat at all.

But the best method of at once improving the health and reducing the weight by increasing the action of the skin, is one which involves no expense and properly followed out supplies as much exercise, in itself, as one could get from a small gymnasium :—

Every morning after washing and thoroughly drying the head and neck, sponge with cold water (and a little soap, but not much if this is done every day) the arms shoulders chest and back, to the waist,—carefully rinsing. Then with a moderately-rough large towel, commence steady but brisk and energetic friction. *Tire* the right arm in drying and rubbing the left, then *tire* the left arm in doing the same by the right. Next tire both arms in drying and rubbing the chest. Now fling the towel over the right shoulder, and holding it with the right hand in front (overarm) and with the left hand behind (underarm), draw it steadily backwards and forwards across the neck, right shoulder, and upper back,—till both arms are again tired. Do the like with the neck, left shoulder, and upper back, interchanging hands. Throw the towel over both shoulders, and alternately pull with right hand and left hand. Keeping the towel still behind, let it fall to a little above the waist, and repeat the steady alternate hauling with right and left hands and arms. You now want a little rest. Take it while you sponge with cold water and a little soap from the waist to the knees and carefully rinse. Tire both arms drying, rubbing, and polishing from waist to knees in front. Pass the towel behind the back as in the last movement of the former series, and haul away alternately with right and left hand, till the back from waist to "small" is glowing and almost burning. Next, let the towel hang under the right thigh, and haul alternately upwards with right and left hands till the back of the right thigh, from seat to knee, is as nearly red hot as possible. Do the like with the left thigh. Again a rest is wanted. So take it while you sponge and rinse both legs from knee to foot. Then lastly, tire thoroughly both arms in drying, rubbing, and polishing both legs from knee to heels and toes. You can now dress at your leisure. There is no fear of taking cold, though you are likely to be rather slow at first, for the arms are or ought to be thoroughly tired out for awhile.

In the evening, just before going to bed, it is a capital plan to repeat the rubbing, without the sponging; or if you sponge at all it should be with warm water, drying before there is any time to feel cold; for the body is not able to bear cold well at night.

By a vigorous rubbing daily, in this way, and still better by two, the skin is kept not only clean, but as soft and free from rugosities as kid, its action is healthily stimulated, and the liver and kidneys are thus relieved from the overwork they have to accomplish when the sudatory glands are left clogged and hampered (as they are with many even of those who daily sponge and daintily dry the whole skin surface).

We come lastly to those forms of exercise which tell most effectively in reducing fat.

(*To be continued.*)

PRETTY PROOFS OF THE EARTH'S ROTUNDITY.

CHIEFLY FOR THE SEASIDE.

By Richard A. Proctor.

(*Continued from page* 86.)

PARALLAX set a vertical mirror at a considerable height above the sea-level to face the sea horizon. Looking into this mirror you saw the sea horizon behind your head in the glass, and apparently at exactly the level of the middle of the eye pupils. Now it is obvious that when you look at your own eyes in a glass, the line of sight from an eye to the corresponding imaged eye is at right angles to the reflecting surface,—and to the glass, if the glass is perfectly even in thickness. Therefore, said Parallax to the bystanders (it was on the Hoe at Plymouth, in 1864, that *I* saw this mirror trick) the line from the eye to the imaged horizon, which you *see* at precisely the same level as your eye pupils, is perpendicular to the vertical mirror, or truly horizontal. Wherefore, my hearers, there is no depression of the sea horizon as astronomers tell us, and as their books show. (Here he had us, for too many of our books *do* show a monstrous depression such as has no existence in nature.)

Many, who *knew* the earth to be a globe looked into Parallax's mirror and were perplexed. His reasoning was correct. If the sea horizon is really depressed below the real horizon, the sea horizon imaged in a vertical mirror ought to be below the imaged eye-pupils; yet apparently it was not below. It looked as if there could be no depression and that the earth's surface must be flat. But they knew right well (many of them were old sea-captains) that the earth's surface is not flat. To one or two, only one solution of the difficulty—to wit, punching Parallax's head—presented itself. Yet this would not have satisfied the company.

XUM

It is easy, however, to see how the difficulty arose, and to devise a way by which a vertical mirror may be made to prove instead of disproving the rotundity of the earth.

Let us see what is the actual depression of the sea horizon, viewed from a goodly height, such as 200 feet.

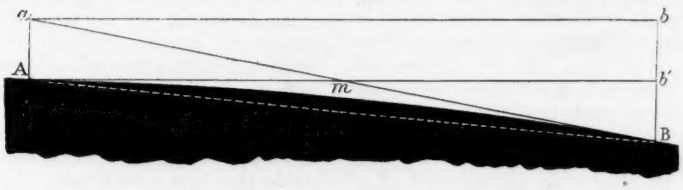


Fig. 8.

Let a (Fig. 8) be the place of the observer's eye, A a being 200 ft.; A B the sea surface; a B the direction of the line of sight from a to the curved sea surface; B b' b vertical at B, and a b the direction of the real horizon. Draw A b' parallel to a b to meet B b in b'. Then obviously B b' = A a = b b' (since B b is appreciably parallel to A a. Therefore B b = 2 A a = 400 ft. Hence the dip of the horizon, or the angle B a b is that subtended by 400 ft. at the distance a B or A m B (appreciably the same). Now (Euclid, Bk. III.) the square on a B is equal to the rectangle under A a and the earth's diameter. Hence with feet for our unit of length

$$a\,B = \sqrt{7920 \times 1760 \times 3 \times 200}$$
$$= 91450 \text{ ft. approximately } (= 17\tfrac{1}{3} \text{ miles}).$$

Now 400 ft. at a distance of 91450 ft. subtend the same angle as 1 ft. at a distance of about 228 ft., or about one-fourth of a degree. This is very different as anyone can see by looking at a circular protractor and noticing how small are the half degrees usually marked in, from the enormous depression usually indicated in pictures supposed to illustrate the globular shape of the earth. The real angular dip of the horizon is only three-fourths even of this, atmospheric refraction diminishing the true or geometrical dip by one-fourth. The real angle of dip is that subtended by 1 (foot or inch or tenth of an inch) at a distance of about 300 (feet or inches or tenths of an inch).

In Parallax's experiment, supposing the eye one foot from the mirror or two feet virtually from the imaged eye, the imaged horizon (if the station were 200 feet above the sea level, would be $\frac{1}{180}$th of a foot or about 4-hundredths of an inch above the imaged eye-level. This would not be discernible by ordinary eyesight, the line of the imaged sea horizon being intercepted by the imaged head. But I shall now show how this difficulty can be removed, and a pretty illustration of the earth's rotundity be obtained by the mirror method.

Let A B C D (Fig. 9) be a rectangular mirror, broad enough to include the imaged face (the breadth of which is always exactly half the breadth of the real face), and to show an inch or two clear on either side, as shown. Let a line a b be drawn with a fine diamond exactly parallel to the sides AB DC. Let the mirror be supported at E and F by rods E G, and F H, which can be fixed into the ground pretty firmly. Let the observer so fix them into a turf sward some 200 feet (say) above the sea level, on a spot commanding a fine sea horizon, putting the face of the mirror seawards. Suppose that at K there is a fine thread K k bearing a blumb-bob P, by means of which the face of the mirror may be made perfectly vertical by suitably turning it on the pivots E F. But as the glass of the mirror may not be of perfectly equal thickness throughout, let the plumb-line admit of being fastened at L, the side D C being made uppermost either by changing the supports or by shifting the mirror in the pivot holes E and F.

After setting the mirror exactly vertical, K uppermost, let the observer retire from it to such a distance—say two yards—that he can see with perfect distinctness not only the pupils of his eyes in the glass, but the diamond line. Let him bring the pupils of his eyes centrally on the line a b. He will then see that the water surface c d is about a quarter of an inch below a b. On the other hand if by slightly lowering his head he brings the water surface to exact coincidence with the diamond line, he will see that the pupils of his eyes are about a quarter of an inch above

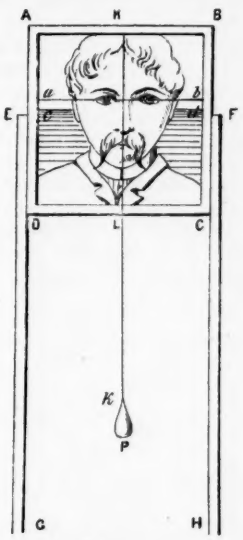


Fig. 9.

that line. Inverting the mirror and letting the plumb-line hang from L, he will get the same result precisely if the mirror is a good one, and very nearly the same result if the mirror is a bad one.

By using a brightly polished plane of steel, which need not be more than four or five inches square, a better result still will be obtained.

But a polished plane of steel four or five inches long and only an inch broad or even less, may be very effectively used without a plumb-line, as follows:—

Fig. 10.

Let A B C D (Fig. 10) be the polished steel plane, set on Se edge of a saucer E F, containing a little mercury (or ink). uppose the cup set on a little platform, admitting of

adjustment by a slow screw movement; and having set A B across the cup, and levelled the cup's surface in direction A B (nothing very exact is needed in this direction), slowly shift the surface in direction square to A B by means of the screw movement, until looking down the face A C its image on the mercury is reduced to a straight line. Then the face A B is perfectly vertical. Now, as before look into the steel mirror A C, bringing the centres of the pupils to the edge A B, as at a, b. The sea horizon will then be seen as at $c\,d$ about a quarter of an inch below A B, if the eyes be about two yards from the mirror.

For different heights, different depressions of the sea horizon will be noted in this experiment. For places near the sea level there is no observable displacement of $e\,f$ below $a\,b$; for places much higher than the 200 ft. of our experiment the displacement is much greater.

Let us see what is the law connecting h the height of the observer, with the angular depression δ of the sea horizon. Call the radius of the earth r. The angle δ is the angle $b\,a$ B of Fig. 8, or (appreciably it is the angle subtended by B b, or twice h, at a distance a B. Now

$$(a\,\mathrm{B})^2 = 2rh \text{ (appreciably)}$$

$$\therefore \delta = \frac{\mathrm{B}b}{a\mathrm{B}} = \frac{2h}{\sqrt{2rh}} = \sqrt{\frac{2h}{r}}, \text{ where a right angle} = \frac{\pi}{2} = 1{\cdot}5708$$

Thus the angle of depression varies as the square root of observer's height. In the above, δ is the geometrical depression-angle. The apparent depression (which may, indeed, be called the real depression, since it is what is *observed*) that we are inquiring about is about three-fourths the geometrical depression.

Let us inquire what height is required to give an observed depression of one degree, which would be very slight—far too slight to be noticed without the aid of instruments. The above equation gives us, since δ, the geometrical depression in this case, is four-thirds of a degree.

$\frac{4}{3}$ circ. measure of 1 deg. $= \sqrt{\frac{2\,h}{3960}}$, taking a mile as our unit of length.

Now, circular measure of $1° = \frac{1}{90}(1{\cdot}5708) = {\cdot}01745$

$$\therefore \text{ squaring, } \frac{16}{9}\,({\cdot}01745)^2 = \frac{2\,h}{3960}$$

$$\text{say (roughly) } 16\,({\cdot}0003045) = \frac{h}{220}$$

$$\text{or } h = 3520 \times {\cdot}0003055$$
$$= 1{\cdot}0754 \text{ of a mile}$$
$$= 5678 \text{ feet}$$

One may say that by ascending to the height of a mile a depression of one degree (apparent) may be observed, if the sea horizon is visible. To attain a depression of two degrees a height of four-and-a-half miles must be attained. This angle would seem very small, scarcely to be recognised by the unaided eye, even if the sea horizon were visible. An ordinary landscape horizon would not seem lowered at all recognisably. Hence the singular optical illusion by which the region visible below a balloon at a great height seems shaped like a vast basin.

(To be continued.)

One Shilling each will be paid for copies of the Index to Volume I. of Knowledge.—Apply or address The Publisher, 75, Great Queen-street, London, W.C.

THE AMATEUR ELECTRICIAN.

BATTERIES.—III.

YET one more "typical" cell before we enlarge on some of the many hybrid cells more or less useful to the amateur in his various experiments.

The Leclanché cell, the form of battery upon which it is our present purpose to dwell, is one which is constantly increasing in its sphere of usefulness, and which will doubtless long continue to hold its own against many of the so-called improvements which the recently increased demand for electrical sources have produced. The cell consists of an outer vessel, generally (for convenience only) of glass; inside this is a porous pot, which contains the negative element. The positive element is in the older patterns a circular rod of good but unamalgamated zinc, immersed in a saturated solution of sal ammoniac or ammonic chloride (NH_4Cl or AmCl). The negative element consists of a rod, plate, or block of gas carbon, embedded in a mixture of the same material, crushed to about the size of peas, and similar-sized manganic peroxide or black oxide of manganese (MnO_2). The last-mentioned is one of those substances so bewildering to the tyro, on account of the multiplicity of their names. The mixture, which should nearly fill the porous pot, should contain approximately equal quantities of its constituents and should be free from dust or very small pieces. A piece of paper, or some such substance is then fitted in the pot over the mixture, and pitch marine-glue, or other impervious material poured over it, so as to keep everything in its place, one or two holes, being, however, provided to facilitate the escape of polarising gases. It will be seen that no liquid is placed in the porous pot, the solution for which is provided by a portion of the sal ammoniac solution passing through the pores of the pot. As the function of the carbon rod is simply that of a conductor, it is apparent that its dimensions are immaterial, the chief feature in connection with it being the necessity for providing it with a cap and connections unassailable by ammonia fumes and solution.

When the zinc and carbon connections are joined, chemical action commences, the zinc is dissolved, and converted into chloride of zinc ($ZnCl_2$) by combination with the chlorine of the sal ammoniac. The other portion (NH_4 ammonium) of the sal ammoniac is further decomposed into ammonia (NH_3) and hydrogen. The hydrogen, which is in what is known as the nascent condition, attacks the manganic peroxide, reduces it to a lower oxide (sesquioxide of manganese, Mn_2O_3), and combining with the released oxygen, forms water (OH_2). The series of exchanges may be represented by equation thus:

$$Zn + 2NH_4Cl + 2MnO_2 = ZnCl_2 + 2NH_3 + OH_2 + Mn_2O_3.$$

Those of our readers who are versed in chemical notation will see that for every volumetric equivalent of zinc dissolved, two equivalents of both the sal ammoniac and the manganic peroxide are decomposed; the solution gradually losing its character and becoming instead a solution of chloride of zinc and ammonia, while the manganic peroxide is gradually reduced to a brownish powder and tends in time to make the mixture in the porous cell muddy and more or less impervious, preventing alike the advent of fresh solution and the exodus of uncombined hydrogen.

It will be seen, on examination, that the Leclanché cell differs very widely from either the Daniell or the Bunsen cell. In the Daniell, it may be remembered, we have the hydrogen from the zinc division attacking sulphate of copper, forming sulphuric acid and copper, the latter being deposited on the negative, or copper, plate, which is there-

fore kept constantly bright and of extreme purity. There being a reservoir of sulphate of copper, the Daniell cell remains constant for weeks. The Bunsen cell lasts but a few hours, the liquid surrounding the carbon, or negative, plate, being rapidly weakened and the plate polarised. In this case, instead of the reduction of a metallic salt by the operation of nascent hydrogen, we get the reduction of a most powerful acid, accompanied by the evolution of highly-irritating fumes. In the Leclanché, the sulphate of copper peculiar to the Daniell, and the nitric acid of the Bunsen, are replaced by a dense black solid, viz., the manganic peroxide. While, therefore, the Leclanché is, in the strict sense of the term, a single-fluid cell, there are, nevertheless, two compounds employed, one for the absorption of the zinc, the other for the absorption of the hydrogen.

The continuous action of the cell is, in consequence of the comparatively weak affinity between the hydrogen and the manganic peroxide, of extremely short duration. It cannot be relied upon for more than a few minutes at a time, and is, therefore, useless where anything approaching the character of a permanent current is required. It, however, soon recovers itself, or, in other words, becomes depolarised.

To make a Leclanché cell (which shall be able to ring a trembling alarm bell through such a length of wire as will reach from the basement to the top story of an ordinary house) the outer cell, which may be of any convenient material, should be of about one quart capacity. It is manifestly not essential that a square glass jar such as we are accustomed to see in the Leclanché cell should be adopted. The zinc may be a piece of half-inch rod—or, better still, a cylinder made from thin sheet zinc. An eighth of an inch would be more than ample thickness, and would help to give a current of increased duration, besides considerably reducing the resistance of the cell. As there is no acid in the cell, and as there is no chemical action going on when the cell is not giving a current, there is no necessity to amalgamate the zinc. The connection should be made by soldering a piece of copper wire or strap on to the zinc, and carefully covering the joint and the wire (except the remote end of it) with some pitchy substance to protect them against the ammoniacal vapours which are evolved as the solution gets saturated. Crushed carbon may be obtained at 2d. per lb., and manganic-peroxide at 3d. The carbon rod will cost a few pence, and will then require to be carefully capped. This is done by first dipping the heated top of the rod in melted paraffin wax, and, after allowing an inch or so of the rod to become saturated, melting on (with the aid of a mould) a lead cap. A brass binding-screw of a compact form should be so placed into the mould as to be fastened into the cap. The cap and exposed parts of the terminal then require to be painted with pitch. These rods, already capped, may, however, be purchased in some places for something less than a shilling. The crystallized sal ammoniac costs 9d. per lb.

Where the Leclanché is only required for a few minutes daily it will last for months without any further attention than the addition of a little water.

The electro-motive force of the cell is 1·5 to 1·6 volts. The resistance varies, of course, with the size, but it is very low, the one above detailed being about 2 ohms.

The peculiar traits of the Leclanché cell preclude its adoption for permanent current working, although modifications of it, to be hereafter described, are being used very extensively in the British telegraph service. Its great forte is its ability to supply powerful intermittent currents at a comparatively insignificant cost. Of the little attention it requires we have already spoken.

As we have now reached the length of our tether, we must defer a few more remarks on this highly interesting cell till another opportunity presents itself.

PLEASANT HOURS WITH THE MICROSCOPE.

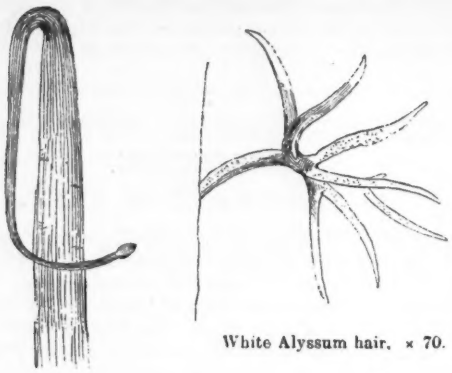
By Henry J. Slack, F.C.S., F.R.M.S.

ONE great advantage of the microscope arises from the facility with which it can illustrate many of the most important principles of scientific investigation. Let us consider, for example, the hairs of plants. First comes the inquiry, What is a plant hair? The popular answer might be, "Anything hair-like that grows from a plant;" but this would not suffice, as many appendages of plants must be grouped with hairs, although they depart widely from the conception of a hair, founded upon the protective and decorative covering of the human head. Take up any hairy leaf or flower-petal, and with a sharp penknife cut some of the hairs off just below their base. It is seen that this may be done by removing a piece of the epidermis, without penetrating into the leaf-substance. Go to a rose-tree, with stout, sharp thorns. Press one of these strongly on one side, and it will break off without injuring the wood of the stem from which it is taken. Next pull a thorn off a small branch of quickset, and some of the wood comes with it. Here, then, is a distinction of importance. Hairs and rose-spines are structures growing out of the epidermis, and in any case all objects ranking as hairs spring "from the layer of cells which always remain outermost in roots, stems, and leaves, whether these outgrowths occur as simple utricular (little bladder-like) protuberances, rows of cells, plates of cells, or masses of tissue, or have the physiological character of woolly envelopes of the young leaves, root-like absorbing organs (mosses), glands, prickles, or spore capsules (ferns)." So says Sachs, in his "Text-Book of Botany." Amongst animals we have some similar variations from soft, thin hairs, to sheep wool, bristles of hogs, cats' whiskers, porcupines' quills, and rhinoceros' horns. The horn of the rhinoceros, says Owen, "consists of a uniform compact mass of epidermal fibres," that is hairs, and much the same may be said of rose-spines. The thorns of May-trees, &c., belong to the wood, somewhat as the horns of deer "consist wholly of bone" (Owen).

There are two different scientific ways of studying the parts or organs of plants and animals—one, the morphological, which investigates how they grow, and from what parent formation; and the other, the physiological, which looks into the functions they perform, or the services they render. It is very often found that parts which are morphologically similar, have quite different uses. Thus, hairs of plants, which protect a young bud or leaf surface, are not like rose-spines, nor in their function the same. Plant hairs which are glandular, and secrete a particular fluid, are different in function from others which oppose a mechanical obstacle to the entrance or exit of certain insects, and thus act as aids to the process of fertilisation. Similar illustrations of similarity of origin and great difference of function abound in the animal world, and as a familiar example, we find the morphologist regarding the biting jaws of the spider as modified feelers (antennæ), and the nipping claws of scorpions as modified maxillary palpi.

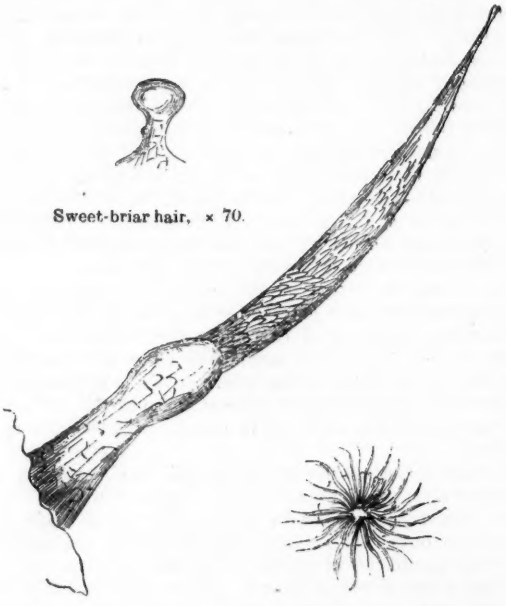
Plant hairs of all sorts recognised by the morphologist are technically called *trichomes*, which means hair-sort of things in origin and structure, whatever may be their use or shape. The simplest hairs are unicellular; other hairs

XUM

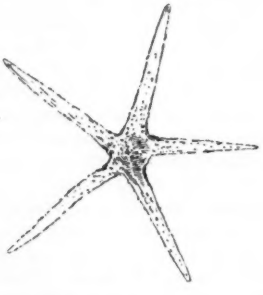


White Alyssum hair, × 70.

Sweet-briar hair, × 70.



Drosera rotundifolia, × 30.



Deutzia scabra, × 70.

Stinging-nettle hair, × 70.

Heritiera minor, × 120.

may have many cells at their base and cellular divisions in the upper part. Round the edge of a sweet-briar leaf are short, stumpy tubes ending in a pretty ruby-coloured gland. Similar hairs, but less brightly-coloured at their tips, are abundant on the under surface of the leaf, and all are glandular, secreting the sweet scent. Extremely beautiful hairs of this type, but longer, decorate the stems of London pride. They form very striking objects when brilliantly lit up and magnified about fifty times. The elegant pink heath (*Erica tetralix*) is similarly ornamented. Glandular hairs may absorb as well as secrete. The remarkable hairs of the Drosera and of other insectivorous plants are illustrations; but the character of Drosera hairs entitles them to be called tentacles. They have a good deal of true leaf structure in them, and the glandular tips are composed of complicated groups of cells. Botanists reckon them amongst the trichomes, but their whole structure shows how close they are to expansions of the leaf, and not, like the simplest hairs, mere outgrowths of epidermis. They are prey-capturing and digesting organs, much like the tentacles of anemones. The short hairs in the middle of the Drosera leaf can convey impressions to the marginal hairs, causing them to close and hold fast the prey which is attracted and caught in the secretion, which gives the popular and pretty name of Sun Dew to the plant. "If an insect adheres to only a few of the glands of the exterior tentacles, these soon become inflected, and carry their prey to the tentacles next succeeding them inwards; these then bend inwards, and so onwards until the insect is ultimately carried by a curious sort of rolling movement to the centre of the leaf" (Darwin). Experimenting with other leaves, Darwin found the glandular hairs on those of two kinds of saxifrage, of a primula, and a pelargonium would rapidly absorb weak solutions of carbonate of ammonia and weak infusions of raw meat. The glands of an erica, a mirabilis, and a nicotiana did not exhibit such a power. With reference to the above observations, Darwin remarked* :—"The glandular hairs of ordinary plants have generally been considered by physiologists to serve only as secreting organs; but we now know that they have the power, at least in some cases, of absorbing both a solution and the vapour of ammonia. As rain-water contains a small percentage of ammonia, and the atmosphere a minute portion of the carbonate, their power can hardly fail to be beneficial, nor can the benefit be quite so insignificant as it might first be thought, for a moderately fine plant of *Primula sinensis* bears the astonishing number of about two millions and a-half of glandular hairs, all of which are able to absorb ammonia brought to them by the rain."

The hairs that form the pappus of thistles and allied plants are sometimes simple, and of others feathered, as in the Carline thistle. On the anther filament of spiderwort (*Tradiscantia Virginica*) the hairs are like chaplets of beads, and each bead shows the cell rotation of the sap, if put in a drop of water, covered, without squeezing, by thin glass, and magnified three or four hundred times. All hairs of plants and trees are said to exhibit this sap movement at some period of their lives.

A shrub, common in gardens, *Deutzia Scabra*, has an immense number of star-shaped hairs on its leaves, chiefly on the upper surface. These are thickened with an exquisite deposit of silex, and are fine objects under the polariscope and a magnification of from fifty to one hundred times.

The rays of the larger Deutzia stars are usually four or five: besides these there are multitudes of smaller stars with many more rays. Similar stellate hairs, but not so big, occur on the smaller-leaved *Deutzia gracilis*.

Many plants have multiple-rayed stars on their leaves. One of them, *Heritiera minor*, a tree found on the coasts of India and Africa, and cultivated in the West Indies, has

* "Insectivorous Plants," pp. 354-5.

the under-side of its leaves so white and shiny, as to be called the Looking-glass Tree. This appearance is caused by sun-rayed hairs, of which a sketch is given.

Sketches are given of various hairs, with their names and magnification employed, drawn from the objects by Mrs. H. Slack.

THE SHOEBILL.

THE Shoebill (*Balæniceps rex*), a singular African bird, is a representative of the family Balænicipidæ. It has a thick neck and large head, and a huge bill, which from its resemblance in size and shape to a shoe has gained for it the title of shoebill.

Wood says: "The bill is enormously expanded at each side of the beak, the edges of the upper mandible overhang those of the lower, and its tip is furnished with a large hook, which is well suited for tearing to pieces the substances on which the bird feeds." It has very long legs and large feet whose long toes are provided with powerful nails, broad and long wings, and a short tuft of feathers at the back of the head.

The general colour of the plumage is a beautiful ash-grey; the edges of the large feathers are bordered with light grey. The eye is bright yellow, the bill horn colour, the foot black.

Young birds are a rusty, brownish grey. The length of the male bird is a hundred and forty centimètres. The female is considerably smaller. These giant birds of the morass, according to the observations of Heuchlin and Schweinfurth, live by pairs or in scattered companies—as far as possible distant from all human settlements, in the huge, almost impenetrable morasses of the White Nile and some of its tributaries, between the fifth and eighth degrees of north latitude. It has not been observed around the other waters of inner Africa. Usually this bird is seen standing fishing in the pools, in the midst of these swamps. It is very shy and cautious, and at the approach of man it rises with a loud rustling noise, and flies low over the reeds, which soon hide it from sight.

If it becomes frightened by the report of a gun, it rises high in the air, circles and hovers around for a long time, and will not return to the water as long as it suspects the presence of man. It is seldom seen on the banks of rivers. When walking it carries its body in a horizontal position, and rests its heavy head on its crop. When flying it draws in its neck. It makes a loud, rattling, cracking sound with its bill, which puts one in mind of the clatter of the storks. Its nourishment consists principally of fish, and it is often seen standing up to its breast in water, and thrusting its powerful bill suddenly under the water, in the same manner as herons do, in order to capture the fish. Petherick asserts that the Shoebill catches and eats water-snakes, and that it also feeds on the intestines of dead animals, the carcasses of which it easily rips open with the strong hook of its upper bill.

Their breeding-time is in the rainy season, during the months of July and August, and the spot chosen for their nest is in the reeds immediately on the water's edge, or on some small, elevated, dry spot entirely surrounded by water. It builds from the dry stalks of the swamp, plants, sod, and mud, a very firm nest often a yard in height. Heuchlin says the eggs are comparatively small, about three inches long and two inches thick; the shell is finely granulated. —*From Brehm's "Animal Life."*

THE MORALITY OF HAPPINESS.

By Thomas Foster.

(*Continued from page* 67.)

THE EVOLUTION OF CONDUCT.

AS structures are evolved, so are the functions which structures subserve. And as the functions of the body are evolved so are those combinations of bodily actions evolved which we include under the general term conduct.

We are considering the functions of the body when we are inquiring into such actions of the various structures internal and external as involve internal processes, simple or complex. But when we begin to consider combinations of actions externally manifested we are dealing with *conduct*,—except only in the case of such actions as are independent of control.

But at the outset of the evolution of conduct even this distinction is scarcely to be recognised. Every external combination of actions is in the lower types of animal life a part of conduct,—at least of such conduct as is possible in the lowest orders of creatures. Evolution of conduct begins with the gradual development of purpose where

at first actions were random and aimless. The *Amœba* wanders from place to place, not by the action of limbs but by a process which may be called diffluence. In so doing it may come into the neighbourhood of objects fit to form its food; these it enwraps, and absorbing what is digestible rejects the rest. Or its wanderings may lead it into the way of some creature by which it is itself absorbed and digested. There may be some higher law than chance guiding the movements of such creatures; but so far as can be judged this is not the case. In other words there is but the suspicion of something like *conduct* in the actions of the Amœba. Among other creatures belonging to the same kingdom, but higher in type, we find actions so much better adjusted, that though even yet we cannot recognise such evidence of purpose as enables us to describe their actions as conduct, we yet see in their adjustment to certain ends the development of something akin to conduct. The actions seem guided by what mimics purpose if it is not purpose itself.

Now we note that with the improved adjustment of actions comes an increase in the average duration of life, or rather in the proportion of this average to the length of life possible among these several creatures.

So when we pass to higher and higher orders of animals, we find in every case among the lower types irregular and seemingly purposeless actions, while among the higher we find actions better adjusted to the surroundings. And again we note that where the combination of actions, or what we may now call the conduct, is not adjusted to the environment, the creatures' chances of life are small, great numbers dying for each whose life approaches the average duration. An improved adjustment of conduct to environment increases the chances of survival, many attaining and some passing the average of longevity in their particular type or order.

Now structural development is guided by the fitness or unfitness of particular proportions in such and such structures for the great life struggle in which all animal life is constantly engaged; and functional development is guided by the corresponding fitness or unfitness of such and such functional activities. Just as certainly the development of conduct in all orders of living creatures is guided by the fitness or unfitness of such and such combinations of external actions for the constant life-contest.

We might find illustrations of this in every kingdom, sub-kingdom, order, and type, of animal life. Let us, however, content ourselves by noting it in man.

In the lower races of man as at present existing, and in still greater degree among the lower races when the human race as a whole was lower, we see that the adjustments of external actions to obtain food, to provide shelter against animate and inanimate enemies, and otherwise to support or to defend life, are imperfect and irregular. The savage of the lowest type is constantly exposed to the risk of losing his life either through hunger or cold, or through storm, or from attacks against which he has not made adequate provision. He neither foresees nor remembers, and his conduct is correspondingly aimless and irregular. The least provident or rather the most improvident perish in greatest numbers. Hence there is an evolution of conduct from irregularity and aimlessness by slow degrees towards the regularity and adaptation of aims to ends, seen in advancing civilisation. The ill-adjusted conduct which diminishes the chances of life dies out in the struggle for life, to make way for the better-adjusted conduct by which the chances of life are increased. The process is as certain in its action as the process of structural evolution. In either process we see multitudinous individual exceptions. Luck plays its part in individual cases; but inexorable law claims its customary rule over averages. In the long run conduct best adapted and adjusted to environment is developed at the expense of conduct less suitable to the surroundings.

With man, as with all orders of animals, conduct which tends to increase the duration of life prevails over conduct having an opposite tendency. Wherefore, remembering the ever-varying conditions under which life is passed, the evolution of conduct means not only the development of well-adjusted actions, but the elaboration of conduct to correspond with those diverse and multitudinous conditions.

To these considerations we may add that the evolution of conduct not only tends necessarily to increased length of life (necessarily, because shortening of life means the diminution of such conduct as tends to shorten life), but it results in increased breadth of life, and (in the highest animal) in increased depth of life also. It is manifest that in the elaboration of activities by which length of life is increased, breadth of life is increased *pari passu*. For these activities may be said to constitute breadth of life. Passing over the numerous illustrations which might be drawn from the lower orders of animal life, we recognise in man a vast increase in the breadth of life as we pass from the limited orders of activity constituting the life of the savage to the multiplied and complex activities involved in civilised life. Increased depth of life we recognise only (but we recognise it clearly) in the most advanced races of that animal which not only thinks and reasons but reflects.

We find then that the evolution of conduct is not only accompanied by increased fulness of life, but is to be estimated by such increase. We do not say that that conduct is good in relation to the individual which increases and that conduct bad which diminishes the fulness of individual life in the individual. We assert, for the present, only what observation shows,—that conduct of the former kind is favoured (other things equal), and therefore developed, in the life struggle, while conduct of the latter sort tends to disappear as evolution proceeds.

Thus far we have only considered conduct in relation to individual life. We have still to consider the evolution of conduct as related to the life of the species.

(*To be continued.*)

LAWS OF BRIGHTNESS.

VIII.

By Richard A. Proctor.

I HAVE hitherto said nothing about the absorption of light, although it obviously affects the brightness of objects. The fact is that in considering the celestial objects we are more directly concerned with the absolute intrinsic lustre of their surfaces, whether that lustre be inherent or imparted. The absorption exercised by our own atmosphere of course affects their apparent brightness; but as a rule we compare their lustre under similar circumstances, selecting also those epochs when, owing to their considerable elevation, the absorptive effects of our atmosphere are as small as possible. And as respects absorptive effects exerted by the atmospheres of the planets themselves we need not specially concern ourselves, because it is, in point of fact, to a certain extent self-compensatory. If a planet possesses an atmosphere so rare and pure that nearly all the light falling upon it passes into and through it to the planet's surface, then, although a greater proportion of the received light is thus exposed to the

absorptive action of the atmospheric medium, yet on the other hand the planet's surface is so much the more brightly illuminated, and the light so illuminating it passes so much the more readily on its return journey through the planet's atmosphere. On the other hand, if a planet's atmosphere is dense, although such an atmosphere much more completely absorbs the light which enters it, yet, on the other hand, it resists the entrance (so to speak) of a much greater proportion, and moreover it is itself illuminated by that which it absorbs. The compensation thus effected may not be, and probably is not complete; but we are precluded (at least until we have much more exact information than has yet been obtained) from discussing satisfactorily the effects due to absorption by the planet's atmospheres. A similar remark applies to the difference between the absorptive effects of a planet's atmosphere near the centre and near the edge of the disc. At the centre more light passes through the atmosphere, and so the planet's surface is more brilliantly illuminated (apart from the consideration of the angle of incidence). At the edge the light has a longer course through the atmosphere, and is therefore much more freely absorbed, so that the planet's surface is much less fully illuminated than it would be if there were no atmosphere. Nevertheless, there is no corresponding falling off in the apparent brilliancy near the edge, for the atmosphere is itself illuminated. Whether this illumination will be greater or less than that which would result if there were no atmosphere, will depend on the nature, extent, and condition of the atmosphere.

Passing from such considerations as these, which are of too difficult and complicated a nature to be here satisfactorily discussed, let us consider how far our estimates of relative brightness are to be depended upon. It must be remembered that in all observations we have to deal with the experience of the senses, and that the senses are fallible. It is important that we should know to what extent the senses *are* fallible in this particular matter of the estimation of light.

Unfortunately, we find the result of such an inquiry not altogether encouraging. There is, perhaps, no subject of research in which the senses are more apt to be deceived than they are in dealing with different degrees of luminosity.

For instance, I have often been asked if it is possible to believe that the faint light of "the old moon in the new moon's arms" is equal to that due to full moonlight; still less, it is urged, can it be equal to that due to full earthlight. Yet the darker part of the moon's disc at the time of new moon is illuminated by full, or nearly full, earthlight. Hence, some imagine that distance must reduce the apparent brilliancy of the light received from that portion of the moon. Of course I do not refer to this mistake for the sake of refuting it, but it affords an excellent illustration of the way in which the senses may be deceived. Let any person look at a distant hill bathed in full moonlight, note carefully its apparent brilliancy, and endeavour to retain the remembrance of it. Sixteen or seventeen days or so afterwards let him observe the young moon, and note the faint light of the part which is not in sunlight, and compare that light with the light of the moon-illumined hill he had formerly observed. It will appear manifest, and so far as the sense of sight is concerned it is manifest, that the light of the hill is far the brighter. Nevertheless, nothing can be more certain than that the light of the old moon is ten or twelve times as bright. The explanation is simple. When we are looking at the new moon, we see the light of the crescent which is illuminated by the sun, and the light of the rest of the disc which is illuminated by the earth. Sunlight exceeds full moonlight some 618,000 times, and it exceeds full earthlight some 50,000 times. It is clear that in the presence of a degree of brightness 50,000 times greater, the brightness of the earth-lit part of the moon must appear by contrast altogether insignificant.

Then, again, we are apt to forget when we are looking at a moonlit landscape, that the brightness of the scene depends largely on the quantity of light, not on its intrinsic brilliancy. Let a small round hole be pierced at the end of a blackened case; let the observer be so covered that he can see only through that hole; and let the hole be so placed as to correspond exactly in seeming magnitude with the full moon: then, if the observer look through that hole at a moonlit hill, he will at once see how utterly insignificant moonlight is by comparison with sunlight. And yet even then the comparison is made under circumstances altogether favourable to the moonlight. For under the darkness in which the observer is enwrapped, the pupil of the eye dilates, and a much larger proportion of light is thus received than would be the case if no such change took place. But let the experiment be renewed at the time of new moon, and in such a way that only the light from the earth-illumined part of the disc is in the field of view; then will the relative superiority of earthlight over moonlight be clearly recognised.

I do not speak at random. I have tried these experiments.

It would be easy to cite multitudes of similar instances. But let us pass from the consideration of eye-estimations of different degrees of light at different times, to consider how far the eye is competent to compare different degrees of lustre observable at the same time.

It is very commonly stated, though not constantly, that the planet Jupiter shows brighter at the edge all around the disc, than in the middle. Certain observations of the satellites serve to show that the reverse is really the case. Noticing a passage in an excellent paper by Mr. Browning on the planet Jupiter, in which the former view was stated, I expressed doubts on the point. "But," said Mr. Browning, "I do not repeat anything I have heard or read on this matter, I describe what I have seen." Knowing that to prove himself mistaken would be quite as pleasant to him as to prove himself in the right, I asked him to take an early opportunity of testing the matter by the use of a carefully-graduated darkening glass. He did so, and found that though Jupiter (when in opposition,—near quadrature there is a difference) *looks* distinctly brighter near the edge than in the middle, he *is* distinctly brighter in the middle than near the edge. The deception is due, no doubt, to the contrast between the edge and the dark sky.

I have very little doubt that the apparent brightness of the moon's edge when she is full is to *some* degree an effect of contrast; though it remains recognisable when the test of the graduated glass is applied.

And here another question suggests itself. What is the effect of either intensifying or reducing in the same degree all the lights of a surface variously illuminated? Intensifying is not easy; since there is absolutely no device by which any surface can be made to look brighter than it is.* Nevertheless, as we sometimes see surfaces less bright than they really are, we may by removing the cause which had diminished the light intensify the apparent brightness. For instance, by travelling south, and getting to the summit of a high mountain, an Englishman can gain

* I am referring to celestial objects chiefly. We may, of course, illuminate a surface more or less brightly; but extraneous light causes perplexity in nearly all experiments on the illumination of terrestrial surfaces.

views of the moon near the zenith considerably brighter than those he can obtain in his own country.

However, the effects of darkening being more readily tested, I select them to consider here.

When we use a very deep darkening glass in the study of the sun, for example, do we leave the relative degrees of brightness unchanged? We may or we may not. The matter is one for experimental research, and such research would be by no means easy. But one thing is certain. We reduce the lower lights in such cases to what appears *to the sense of sight* as absolute blackness—*zero* in our light scale—and we leave the brighter parts with a degree of light which is not zero, but a finite quantity. Now, since the smallest finite quantity exceeds zero in an infinite degree, we clearly have affected the apparent proportion between the brighter and darker parts of the sun in such sort that it no longer corresponds to the true proportion; for assuredly the light of the brighter parts of the sun does not infinitely exceed that of the darker portions.

Thus it is seen that in this instance, at least, we cannot safely assume that the relative brightness of surfaces variously illuminated, is left unchanged by a common darkening which theoretically should affect each in the same proportion.

I think this will be enough to show how important it is in all questions relating to brightness to consider the possible action of physiological causes. We ought to multiply our tests in order to evade deception, and not be too sure even then that we may not remain to some degree deceived by our senses.

(*To be continued.*)

THE DEATH OF CAPTAIN WEBB.

THE *New York Times* gives some particulars of the finding of Captain Webb's body. A correspondent at Niagara Falls states that about ten o'clock on the morning of July 28 a stonemason named Turner was crossing the river in a small boat, about one and a half mile north or down stream from Lewistown, when he discovered the body floating face down, only a few rods out from the American shore, floating down with the current. He took it to Lewiston, where it was identified a few hours afterwards. The cloth was still around the loins, and the body appeared to have suffered little from the rude force of the water. It was found a little less than four days after it entered the Whirlpool, which is a remarkable fact, as bodies passing into the dreadful vortex often remain there a whole week before being discharged into the Rapids below. A striking illustration of the shifting nature of the currents of the Niagara River above and at Lewiston has occurred contemporaneously with the melancholy case of Captain Webb. On Monday, July 23, rather more than twenty-four hours before Captain Webb dived from McCloy's boat above the Suspension Bridge, a number of Indians clambered up the rough and precipitous bank on the American side to a point called the "Rocks" above Lewiston, and about midway between that place and the Suspension Bridge.* The river there is a narrow and foaming torrent, though less frightful than the Whirlpool Rapids. Yet it is in the few yards of swift, unbroken water next the shore at this point that the Indians have long been accustomed to bathe, and it is their favourite place for learning (*sic*) their boys to swim. Two of them, while bathing, ventured a little too far out, were caught by the roaring torrent, and hurried down the river like two corks. Their companions witnessed their fate, but were of course helpless to aid them. The bodies must have been detained by the deep-water eddies above Lewiston for five days. Within an hour of the time of the finding of Captain Webb's body the bodies of these two Indians were found at a spot only two miles from the place where they entered the water. On July 31, an inquest was held on the remains of Captain Webb. On the previous day Mrs. Webb, in company with her late husband's manager, Mr. Kyle, arrived at Niagara Falls from Boston. On viewing the Rapids, she said she believed her husband could swim safely through them, and that he was killed by striking the rocks. Mrs. Webb and Kyle identified the body, and Dr. Palmer, of Lockport, who made the *post-mortem* examination, testified that he thought the reactionary force of the water had paralysed the nerve centres, and rendered breathing impossible.—The jury found a verdict that Captain Webb came to his death while attempting to swim the Whirlpool Rapids, but that they were unable to determine the immediate cause of death.

* See Map of the Niagara Falls and Rapids, p. 72.

THE Glasgow *Weekly Mail* says:—"It is understood that the Town Council have resolved to raise an action in the Court of Session to compel the North British Railway Company to remove the ruins and *débris* of the old Tay Bridge before proceeding with the erection of the new one. The Council, in taking this step, are believed to be proceeding upon the opinion of eminent Parliamentary and Scotch counsel as to their rights under the last Tay Bridge Act. The clause relating to the subject definitely states that the company are bound to remove the ruins and *débris* of the old Tay Bridge, and that the Town Council may force them by legal action to do this, but no time is stated within which the work shall be done."

THE soap-bubble colours upon glass are produced by a vapour, which is deposited on the hot glass before it goes into the annealing oven. According to the *Bulletin de la Société d'Encouragement* the vapour comes from a mixture of protochloride of tin, carbonate of baryta, and carbonate of strontia. It is said that the workmen of a Bohemian manufacturer, wishing to celebrate his arrival, kindled some Bengal lights in the annealing furnaces, and the pieces which were in the furnaces all became iridescent. The colours can be removed by hard rubbing. Messrs. Clémandot and Fremy produced a pearly lustre, like that of shells, by means of different chemical agents, chlorhydric acid among others, under pressure of four, five, or six atmospheres.

THE *Engineer* notes that an important meeting of the directors of the principal steamship insurance companies in the North of England was held last week at Newcastle, to take into consideration the report of a sub-committee which was recently appointed to investigate sundry allegations of unfair dealing by some of the shipowners in that district. These gentlemen, it appears, have been in the habit of receiving large discounts off their repairing accounts without placing them to the credit of the insurance companies, who in this manner have, in the single case under consideration, been bled to the extent of several thousand pounds. It is stated that the shipowners offered a sum of no less than £10,000 to settle the matter. This, however, has not been accepted, and at the meeting it was unanimously agreed that the steamers belonging to the firm in question should not be insured any longer in the various societies which were there represented. We understand that several other cases of a similar character are now under investigation, while strict inquiries are being made in certain quarters where dealings of the same kind are suspected.

THE FACE OF THE SKY.

FROM AUGUST 17 TO AUGUST 31.

BY F.R.A.S.

THE recent exhibition of increased activity on the surface of the sun will, of course, prompt the student to keep a sedulous watch upon the solar disc for its consequent phenomena. Such a spectacle as that described by Mr. Slack (p. 70) will afford an ample reward for any amount of watching. The night sky will be found delineated on Map VIII. of "The Stars in their Seasons." Mercury is but indifferently placed for the observer, but may just possibly be caught on a very clear evening after sunset, close to the horizon and a little to the south of west. Venus remains, for our present purpose, invisible; as do Uranus and Neptune. Mars rises before midnight, almost in the north-east. His telescopic diameter is too small to enable the observer to examine his surface. He still presents the appearance of a blazing red star, and is situated to the north-east of ζ Tauri ("The Stars in their Seasons," Map I.). Jupiter has not yet come into sight. Saturn rises, of course, sooner and sooner every night, appearing above the north-east by east point of the horizon about 10 p.m. at the end of August. Hence, by midnight, he will be some 18° high, and fairly well observable. He is moving slowly to the eastward in that void part of the sky north-east of ε Geminorum (Map I.). The moon is 14·4 days old at noon to-day, and, quite obviously, 28·4 days old at the same hour on the 31st. Hence, after about the 25th she will be but poorly placed for the observer during the working hours of the night. Two occultations of stars will occur during the fourteen days covered by these notes. The first will happen on the 21st, when the 4th magnitude star ε Piscium will disappear at the moon's bright limb at 12 h. 20 m. p.m. at an angle from her vertex of 155°, and reappear from behind her dark limb at 12 h. 42 m. p.m. at an angle of 197° from her vertex. The second occultation will be that of the 6th magnitude star B. A. C. 1206, which, on the night of the 24th, will disappear at the moon's bright limb at 10 h. 30 m. at an angle of 73° from her vertex; re-appearing at her dark limb at a vertical angle of 235° at 11 h. 21 m. p.m. During the whole of to-day and to-morrow, and, in fact, until 6 p.m. on Sunday, the 19th, the moon will be travelling through Aquarius, from which constellation, at the hour named, she will pass into Pisces. She will not quit Pisces until 9 p.m. on the 22nd, when she will travel into Aries. She will occupy until 1 p.m. on the 24th in crossing Aries, and will enter Taurus between 1 and 2 o'clock on the afternoon of the latter day. She continues in Taurus until 1 a.m. on the 27th, when she begins to cross the northern part of Orion. This occupies her until 2 p.m. on the same day. She then emerges in Gemini, and remains in that constellation until 7 a.m. on the 28th, at which hour she enters Cancer. It will be 11 o'clock at night on the 30th before she reaches Leo. There she continues until 10 p.m. on the 31st, when she descends into Sextans. We there leave her.

IN 1871 the total population of the seven Australasian colonies—which include the five Australian colonies, viz., Victoria, New South Wales, Queensland, South Australia, and West Australia, and the colonies of Tasmania and New Zealand—was only 1,978,740. In 1881 the total population was 2,835,954, showing an increase in ten years of 857,206, or an average of 85·7 per cent. Ten years ago the combined exports of the same colonies amounted to approximately £67,000,000, and in 1881 to £105,000,000, showing an advance of more than 50 per cent. This is equal to about £38 per head of population. The public revenue of the seven colonies during the year 1881 amounted to about £21,000,000, against £18,000,000 in 1880, being an increase of £3,000,000. The colonies possess 5,426 miles of railway, 49,105 miles of telegraph, 78,000,000 sheep—the wool clip of which last year realised the sum of about £21,000,000—besides 8,691,910 cattle, and several millions of horses and pigs. During the year 1881, 16,690 vessels, of an aggregate tonnage of 9,504,130, touched at the various ports of the colonies. The same colonies have 7,017,380 acres of land under profitable cultivation, and produce annually about 30,000,000 bushels of wheat, and 11,717,819 bushels of oats. Of these latter New Zealand alone produces 6,924,848 bushels.

"Let Knowledge grow from more to more."—ALFRED TENNYSON.

Only a small proportion of Letters received can possibly be inserted. Correspondents must not be offended, therefore, should their letters not appear.

All Editorial communications should be addressed to the EDITOR OF KNOWLEDGE; *all Business communications to the* PUBLISHERS, *at the Office, 74, Great Queen-street, W.C.* IF THIS IS NOT ATTENDED TO DELAYS ARISE FOR WHICH THE EDITOR IS NOT RESPONSIBLE.

All Remittances, Cheques, and Post Office Orders should be made payable to MESSRS. WYMAN & SONS.

The Editor is not responsible for the opinions of correspondents.

NO COMMUNICATIONS ARE ANSWERED BY POST, EVEN THOUGH STAMPED AND DIRECTED ENVELOPE BE ENCLOSED.

PRESCRIBING FOR CHOLERA.

[896]—With reference to the letter appearing on page 60 of KNOWLEDGE, July 27, 1883, headed "Cholera" (preventive), I wish to make a few remarks.

In the first place, the reverend gentleman should have defined cholera as he understands it and prescribes for it. Judging by the tenour of the letter, he draws no distinction between cholera and diarrhœa in its severer forms. Now, it is hardly necessary to say that a primary essential to correct and rational treatment is to understand what disease has to be dealt with.

Again, filtration of water is not sufficient; it is necessary to boil it and preserve from absorbing impurities present in the atmosphere, which it will do readily on cooling. It cannot be too clearly understood that no prescription is indiscriminately applicable to several cases. In diarrhœa, pre-eminently, the treatment of a given case will depend upon its cause, and the sooner the doctor sees the case the better. It is folly to trifle away time that may be of vital importance. Why the crudely and imperfectly transcribed prescription should be called an "Indian remedy" I cannot imagine—nor can I imagine how an educated man can so lack in ordinary etiquette as to publish the result of other men's labours without attempting to acknowledge whence the information was derived. I take this opportunity to draw attention, through the columns of your journal, to the obvious irregularity of a clergyman taking upon himself to prescribe—unfortunately, of not infrequent occurrence. Surely a very recent example should prove a warning.

A READER.

[We agree with "A Reader," that there is an objection to publishing prescriptions in such organs as KNOWLEDGE, HEALTH, &c., even though such prescriptions may have high medical authority in their favour. The prescriptions may be good but their application may be bad. "Won't do so any more."—R. P.]

GIRTH AND THE PARCEL POST.

[897]—It may be useful in view of the coming operations of the Parcel Post to inquire minutely into the restrictions which the authorities impose upon the size of the parcels that may be sent. These are—Maximum length, 3 ft. 6 in.; maximum length and girth combined, 6 ft.

The first presents no difficulty. A parcel has of necessity, like any other solid body, length, breadth, and thickness—*i.e*, it has three dimensions. The above restriction simply requires the greatest dimension to be less than 3 ft. 6 in.

When we come to the second restriction we are met by the word "girth." Now girth is a good old Saxon word, and is connected with girdle. The scientific idea presented to the ordinary feminine mind is "how much round the waist?"—unless, indeed, the answer come from a Girt(h)onite, and then something very precise may be expected.

The word girth may be paraphrased circumference or perimeter. The old mathematical term is periphery. Imagine a solid cylindrical pillar of circular section, such as may be seen in many churches and cathedrals. Suppose it were required to calculate the number of cubic feet in such a pillar the height of which was known. A string passed round would give the girth, say 10 ft. Since the circumference of a circle is three and one-seventh times its diameter, this would give the diameter about 3 ft. 2 in. Whence the area of

XUM

the circular section and consequently the cubic contents of the pillar could be obtained.

Now, imagine the pillar to become very extensively dwarfed, so as to meet the requirements of the parcel post; its length to be 3 ft. 6 in., and its girth consequently 2 ft. 6 in., so that the two are together 6 ft. Proceeding as before, we should get the diameter of the circular section very nearly 10 in. If, then, we conceive a cylindrical parcel about a yard in length, and each end about the size of a dinner-plate (10 in. in diameter), this will represent the required limits.

When the parcel is shaped like an ordinary box the girth becomes twice the breadth and thickness together; or, if the section be square, four times the edge of one end. The longest box, then, that can be sent is one 3 ft. 6 in. in length, and the edge of whose end is 7½ in.

If the box be of cubical shape the length of its edge must be one-fifth of 6 ft.; or about 1 ft. 2 in.; and this is the greatest-sized cubical box that can be sent.

It may be shown by the differential calculus that the largest content to be got out of the box shape is when the dimensions are 2 ft., 1 ft., 1 ft. or two cubes of 1 ft. placed face to face. For the cylindrical shape this becomes length 2 ft. (as before), and girth 4 ft. giving a circular section of about 15 in. diameter.

R. F. Davis, M.A.,
Cambridge, Queen's College; Member of the London Mathematical Society.

AUDITORY FANS.

[898]—The fans, &c., spoken of in your answers to correspondents under C. Thompson, are sold with all particulars at a shop next door to St. Saviour's Deaf and Dumb Church, 419, Oxford-street. Xox.

THE VORTEX-ATOM THEORY.

[899]—The vortex-atom theory, viewed from the physical side, is regarded by some as one of extreme simplicity. I must confess, however, that to me it appears to be far otherwise. In fact, I am unable to understand how the theory is to be reconciled with the first law of motion. According to that law no body possessing inertia can deviate from the straight line unless forced to do so. A planet will not move round the sun unless it be constantly acted upon by a force deflecting it from the straight path. A grindstone will not rotate on its axis unless its particles are held together by a force preventing them from flying off in a tangent to the curve in which they are moving. Centrifugal force must always be balanced by centripetal force. My difficulty is to understand what force counterbalances the centrifugal force of the rotating material of the vortex-atom. It has been said that the centrifugal tendency of the rotating material of the vortex-atom is controlled by the exterior incompressible liquid. But it is also stated that this incompressible liquid offers no resistance whatever to the passage of the atom through it. In short, that in so far as the motion of the atom is concerned this liquid is a perfect void. Now, if this liquid can offer no resistance to the passage of the atom as a whole, how then does it manage to offer such enormous resistance to the materials composing the atom so as to continually deflect them from the straight path and compel them to move in a curve? The centrifugal force of these vortex-atoms must be enormous, for on it is assumed to depend the hardness or resistance of matter to pressure. Now the centripetal force which balances this centrifugal force must be equally enormous. Then if this perfect fluid outside the vortex-atom can exert this enormous force on the revolving material without being itself possessed of motion, then there does not seem to be any necessity for vortex-motion in order to produce resistance.

It has further been advanced, by way of explanation, that this incompressible liquid surrounds the revolving liquid like a pipe, "and that if the liquid in this pipe were to fly out, a temporary void would be formed in it, which is impossible in a liquid that already occupies all space." The incompressibility of the surrounding fluid surely cannot be a reason why portions of the revolving material do not fly out, for if incompressibility could prevent portions of the revolving atom from flying away, it would equally prevent the whole atom from doing so, but according to hypothesis this incompressible fluid offers no resistance to the motion of the atom. When the atom moves it is assumed that the fluid in front is displaced; but then this simply makes room for an equal quantity behind, and thus no void is formed. The very same thing ought to take place, though only a portion of the atom were to fly off. The various portions of this revolving material are not supposed to be held together by any cohesive force like those of the grindstone. What then prevents the revolving material from being dissipated by the centrifugal force of rotation? In short, how is the existence of the atom possible under the physical conditions assumed in the theory? James Croll.

LETTERS RECEIVED, AND SHORT ANSWERS.

L. A. B.—The small magnets would very speedily have their polarities reversed by the more powerful fixed magnets, and resistance to rotation would ensue. Supposing, however, that the polarities were unaffected, the action would be in character with that which would result if a diamagnetic substance were substituted for the small magnets—that is to say, resistance to motion would evidence itself. It will be seen that although repulsion would be exerted upon receding and approaching magnets equally, resistance to motion would be experienced owing to the "squeezing" effect exerted upon the magnets *between* the fixed poles—S. Quint. If we had a telescope of the power you mention, the movements of Jupiter's surface would undoubtedly be magnified in the same enormous degree, and unless the effect of his rapid rotational motion were corrected there would be a rapid rush of the features across the field of view, with the blurring you speak of; but it would be the easiest thing in the world to correct this by the use of clockwork, keeping the telescope directed to a fixed point on any zone. In that case there would be no blurring at all.—E. A. Rowe. I am no arbiter of literary tastes. Nearly all the works you mention are popular.—F. Pitman. Have not seen the former work. A notice such as you send me would imply that I had and approved of it.—Geo. Jordan. What *will* you ask next? You want me now to explain why the moon is always full in the Arctic regions, why she never sets there,—and again you ask, "Can it be possible that there is a south pole as well as a north pole and the moon when crescented goes round the north centre and when at full she goes round a south centre?" And yet again, when I say the moon is every month half the time north of the celestial equator and the other half south, you "suppose in that case," I "refer to the month of June especially and only in June." (Now, *is* June *every* month?) Will you permit me to inform you, once for all, that the moon's behaviour in both the Arctic and Antarctic regions is precisely the same so far as her apparent form is concerned as it is anywhere else. When the moon is full here she is full *wherever she can be seen*, when gibbous gibbous, when crescent-shaped crescent-shaped. The moon is seen in the Arctic regions (and here, be it noticed, I am speaking of places well within the Arctic circle, not upon or *just* within it, but say north of seventy-two or seventy-three degrees) during part of every month, the particular part of each lunar month in which she is best seen varying as the year goes round. In December she is full when highest above the celestial equator, and consequently she is then visible as a full moon all through the night. In high Arctic latitudes she is visible in December all through the night from a few days before full to a few days after full. In January the part of the lunar month when the moon is seen all night ranges over a week or so, in high latitudes, to about the time when she is full. In February the week during the lunar month when the moon is visible all through the twenty-four hours ends a few days before the time of full moon. In March it ranges equally on either side of "half-moon before full." In April it ends at about the time of half-moon before full; and in May a few days earlier. In June there is no night, at least towards the end of the month; and at this time the moon is only visible above the horizon all through the twenty-four hours when near the sun or appearing as a fine crescent. She is invisible all through the twenty-four hours when nearly new in December near the time of midwinter; for about a week, ending at time of new moon, in January; a few days earlier in the lunar month in February; for a week equally divided on either side of half-moon after full in March; for a week ending at about half-moon after full in April; and a few days earlier in the lunar month, in May. The moon is invisible all through the twenty-four hours when nearly full near the time of Midsummer—in high Arctic latitudes—*i.e.*, four or five degrees north of the Arctic circle. You should find no difficulty in extending these considerations to the remaining months. Again, for the Antarctic regions, you have only to write July, August, September, October, November, and December, respectively, for December, January, February, March, April, and May, in the preceding account, to have a correct description of the phenomena there. You are bound to tell me that some of your old captains deny all this, and say the moon is always full in the Arctic regions, never sets there, can be seen full in high arctic latitudes at midsummer, and so forth. But besides these old captains there have been, let me remind you, sundry old Arctic captains not altogether unknown to fame, such as Sir E. Parry, Sir Jas. Ross, McClintock, and a few others, who have not—like yours—tried to recall, with obviously imperfect memories, what they

think they fancy they remember they saw, but have carefully noted all observed phenomena. It is hardly necessary to say that in all the multitudinous volumes of Arctic and Antarctic travels extant, no such absurdities as your old sea captains have told you are mentioned; but the moon, the guide of the sailor in remote seas, behaves within the Arctic circles as she behaves elsewhere; she is new, half full, gibbous, and full at the times given by the "Nautical Almanac" for the whole world; and in fact if she has anything at all to say to your sea captains' stories, informs you simply that either they have blundered, or (which is far more probable) they have amused themselves by telling old "forecastle yarns" for your edification.—H. Askew. (1.) The geometrical problems will probably be published. They were submitted, almost in their present form to Messrs. Longmans, in 1868, who submitted them to Professor Goodeve and Mr. Cock, mathematical lecturers at King's College, who studied them so carefully as to find out that the problems might be *more simply solved*—as if it were the object of the papers to show how those particular problems might be most briefly solved. (2.) We have unfortunately no space for obituary notices in Knowledge, except in the case of a few very eminent men such as Darwin, J. W. Draper, H. Draper, &c., whose influence on the advance of scientific thought has been very marked. (3.) The Harton Coalmine experiments gave 6·565 as the mean density of the earth. Mr. Sketchley probably means that this result raised the average of the best estimates to 5·480.—F. M. Duplock. Pray excuse the misspelling of name; "I" was not responsible for the mistake, but the fault was as you say with "U"; only U say this and I say it with different significance. Thanks for kind inquiries as to effects of railway accident. Have felt the shaking a good deal; but hope effects will shortly pass off. Though sitting with my back to the engine, only my knees show any marks! both of them bruised by the counter shock,—in other words I "cushioned" off the seat behind me on to my knees on the seat in front of me, with enough force to mark them both and to bark one. Rather an unusual way of bruising the knees!—G. S. See solution in our columns.—E. Const. May. Write down the first three odd numbers in order, each repeated twice,—thus 113355, and divide the latter half of the number thus formed, 355, by the former half, 113. The result is the ratio of the circumference to the diameter of a circle, correct to the first six decimal places: for the quotient is 3·1415929, &c., which to the sixth decimal place would be written 3·141593 as would the true ratio, which is 3·14159265, &c.—W. E. Drinkwater. The sun and moon both rule the tides, their respecting tide-raising influences being as the numbers two and five. When they combine their influence, the tidal wave bears to the lunar tidal wave about the ratio of seven to five; while, when they oppose each others' influence, the tidal wave is less than the lunar tidal wave (*i.e.*, the wave which there would be if the sun excited no effect) as three to five. Thus the solar influence produces no tidal wave separate from the lunar wave, but is, as it were, merged in the lunar influence. The tidal period follows the moon, but the variation of the tidal wave in height follows the sun.—T. M. Your theory is presented with assertion only. "The fact should be familiar to all," you say, and go on to give as a fact what is not only not familiar to all, but not a fact at all. As to alluvial and diluvial matter, astronomers find plenty of evidence of that in the moon; but perhaps this, being a fact, is not familiar to you.—T. C. Fear many readers would not see that you are jesting in finding "the number of the beast" in the name of the great and good man you mention—preposterous though the notion is. Some really do fancy they see the cloven hoof there,—not being quite able to see above his instep.—R. F. Kerr. You are right in thinking that I utterly decline to answer your question. I simply cannot tell you what I do not know myself. If Knowledge cannot be honestly sold unless the editor tells you what he understands by what neither he nor any man who has ever lived *can* understand, then Knowledge must continue to be (in your opinion) sold dishonestly.—J. C. S. That *Daily Telegraph* article about the midnight sun, earth's inclination, &c., belongs to a type which I had thought played out. It is nearly all nonsense, of course. If there were such a change as supposed, the present forms of vegetation in the temperate and Arctic regions would no longer be so well suited as they are at present. As for sudden change in earth's centre of gravity, that is nonsense, too. Adhémar's theory was wild enough in all conscience, without adding that absurdity.—W. Aston. I really do not know how you should set about to get a "certificate" to "an able" you to teach and pass pupils.—Geo. Howard. Pardon me, though you may have taken in Knowledge from the first, you are not an original subscriber. A copy of the index was sent gratis to every subscriber. It most assuredly is not the proprietor's duty to reprint the index at heavy cost, because one or two failed to provide themselves with it when it was issued. I differ from you altogether as regards the Whist Column. It has been discontinued during chess tourneys, but it will be resumed soon. Whist has as good a right to be described as a scientific game as chess or draughts.

Our Mathematical Column.

GEOMETRICAL PROBLEMS.

By Richard A. Proctor.

PART XII.

LET us next try the following problem:—

Ex. 18.—*Determine the locus of the middle points of all the chords of a circle which pass through a fixed point.*

The fixed point may be either within or without the circle. In nearly all cases of this sort it is well to begin with a point within the circle, trusting to the result thus obtained to guide us in the case of a point without the circle.

Let P (Fig. 27) be a point within the circle A B C D. We are to draw chords through P, and to bisect them. Draw, first, the diameter A P E C through P. Its bisection, E, is the centre of the circle. This is one point of the required locus. Draw next the chord B P D at right angles to A C. Then the point P is itself the bisection of D B (Euc. III., 3). Therefore P is a point on the required locus. Next draw a chord F P H G through P, and bisect in H. Then H, a point on the locus, is clearly not in the straight line joining P E, so that the locus is not a straight line. It is, therefore, probably a circle. Now we see at once that for every point we get above A C there must be a corresponding point below A C. We see, then, the probability that the required locus is a circle of which P E is the diameter. But even if the student failed to see this at once, he would readily detect it when he had drawn several more chords through P (above and below P C), and bisected them. We describe, therefore, a circle C H P, of which we assume P E to be the diameter, and we look for a proof that a chord drawn as F P H G *would* be bisected in H where it meets the circle thus drawn. It will clearly be well to join E H. When this is done, one of two well-known properties can hardly fail to occur to our mind. We might either remember that the angle in a semicircle being a right angle,

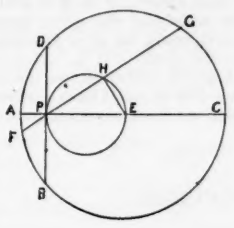


Fig. 27.

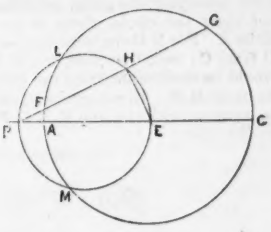


Fig. 28.

E H will be at right angles to F G, if P H E really is a semicircle, or we might remember that the line from the centre of a circle to the bisection of any chord is at right angles to the chord, so that the angle E H P is a right angle independently of any consideration of the assumed circle P H E. Of course, if we thought of the first property we should be led immediately to the second, and *vice versâ*. The two properties are, in fact, interdependent; and we see at once that their interdependence involves the solution of our problem.

We now write out the solution in the following form:—

Let A B C D be the given circle, P the given point.

First, let P lie within the circle. Draw any chord, F P H G, and bisect F G in H. Find E the centre of the circle A B C D, and join E H. Then E H is at right angles to F G (Euc. III., 3); therefore H is a point on the circle of which P E is a diameter. (Euc. III., 31). But F G is any chord through P. Therefore the bisections of all such chords lie on the circle E H P. Also it is clear that every point on this circle bisects some chord through P; therefore, this circle is the locus required.

Next, let P lie without the circle (Fig. 28). Then the proof is the same* up to the words, "therefore the bisections of all chords

* It is important to notice that in such a case as the above, *by putting the same letters at corresponding points in both figures*, the proof of one case may be made to apply to the other, either without change, or with such obvious changes as the student can have no difficulty in making.

XUM

through P lie on the circle E H P." But it is clear that points on the arc L E M bisect chords through P; and also that *every* point on this arc bisects *some* chord through P.

A readiness in determining the loci corresponding to different conditions will often be found serviceable to the student engaged in solving problems of different classes.

Suppose, for instance, that the following problem is set:—

Ex. 19.—*Let A, B, C (Fig. 29), be three given points, D a given straight line. It is required to find a point which shall be equidistant from the points A and B, and at a distance from C equal to the line D.*

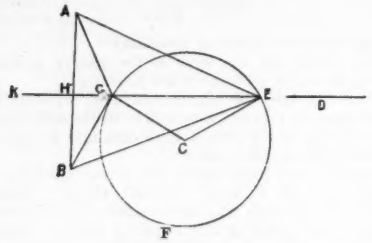


Fig. 29.

In order that the distance of the point from C may be equal to the line D, it is clearly necessary that the point should lie somewhere on the circumference of the circle described with centre C, and radius equal to D. Let G E F be this circle.

Next, we inquire whether there is any *locus* containing all points equidistant from A and B. We join A B and bisect in H, giving one point, H, clearly belonging to such a locus. Next, either by applying tentative methods, as in the above instances, or by the consideration of a few obvious facts, we find that the indefinite line, K H G E, drawn through H at right angles to A B, contains all points equidistant from A and B. The line K H G E does not *necessarily* intersect the circle F G E. If it intersects that circle in two points, G and E, it is clear that each of these points satisfies the required conditions. For C G is equal to D (*const.*), and G A is equal to G B (Euc. I., 4. See also Ex. 1.) Also, C E is equal to D and E A to E B. If K H G E touch the circle there is only one point satisfying the given conditions. And clearly, if K H G E do not meet the circle, there is *no* point satisfying the given conditions. For if there were such a point, it would be at a distance D from C; and, therefore, would lie on the circle F G E. Also it would be equidistant from the points A and B, and therefore would lie on K H E. In other words, the circle F G E *would* have a point in common with the line K H G E, which we have supposed not to be the case.

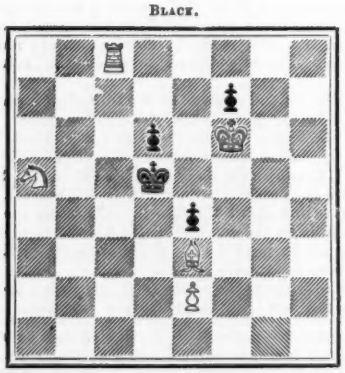
Our Chess Column.

By Mephisto.

PROBLEM No. 92.

By J. C.

Black.



White.

White to play and mate in three moves.

GAME PLAYED RECENTLY BETWEEN MEPHISTO AND ANOTHER STRONG PLAYER (SCOTCH GAMBIT).

White. Mephisto.	Black. Amateur.	White. Mephisto.	Black. Amateur.
1. P to K4	P to K4	10. Kt to K4	B to Kt3 (*f*)
2. Kt to KB3	Kt to QB3	11. P to B4	Kt to Kt5
3. P to Q4	P takes P	12. Kt to B6 (ch) (*g*)	P tks Kt (*h*)
4. Kt takes P	Kt to B3 (*a*)	13. B tks P (ch)	K takes B (*i*)
5. Kt takes Kt	KtP takes Kt	14. Q to R5 (ch)	K to Kt sq
6. B to Q3 (*b*)	B to B4 (*c*)	15. Q to Kt4 (ch)	K to R2
7. P to K5	Q to K2	16. Q to R4 (ch)	K to Kt sq
8. Castles	Kt to Q4	17. P takes P	Resigns (*j*)
9. Kt to Q2 (*d*)	Castles (*e*)		

NOTES.

(*a*) This defence was adopted by Zuckertort in his match against Blackburne. It leads to a difficult game for Black.

(*b*) Steinitz is of opinion that the P should at once advance to K5.

(*c*) P to Q4 ought to be played here; it is the principal move in Black's defence, for if White plays P to K5 the Kt can conveniently retire to Q2.

(*d*) Here P to QR3 first might have been preferable.

(*e*) Castling is always dangerous when all the pieces are placed on the Q side, and especially when the adversary's B is posted on Q3. Black ought to have played Kt to B5 instead, which would have enabled him, if necessary, to play Kt to K3, but his position was a difficult one to handle.

(*f*) If P to B4, then 11. P takes P *en pas*, Kt takes P. 12. B to Kt5.

(*g*) This combination forces the game.

(*h*) Obviously Black could not reply with K to R sq., on account of 13. Q to R5, P to KR3. 14. QB takes P.

(*i*) Here again Black has no resource but to accept his fate; if K to R sq., then 14. B to B5 threatens mate by Q to R5, or, if K to Kt2, then Q to Kt4 (ch) brings about the same position.

(*j*) There was no feasible way of preventing the threatened mate on Kt7; an interesting variation arises from the following play: B takes P (ch). 18. K takes B best (R takes B would be bad on account of Q to K8 (ch), and the R could not cover; Q takes B would be good, but it would render winning a little more difficult,) Q to B4 (ch). 19. K to Kt3, Q to Q3 (ch). 20. R to B4, Q to Q6 (ch). 21. K to B2, Q to R2, best. 22. Q to Kt3 (ch) and wins the Queen.

Contents of No. 93.

	Page
Vesuvius and Ischia. By R. A. Proctor	81
The Birth and Growth of Myth. XIII. By Edward Clodd	81
Pretty Proofs of the Earth's Rotundity. (*Illus.*) By R. A. Proctor	84
The Moon in a Three-Inch Telescope (*Illus.*) By F.R.A.S.	86
Weather Forecasts, and How to Make Them. By John Browning	87
The Fisheries Exhibition. IV. (*Illus.*) By John Ernest Ady	87
Sea Anemones: The White Carnation. (*Illus.*) By T. Kimber	89
A Steamer goes Safely Past Niagara Whirlpool	90
Principles of Dress Reform. By E. M. King	91
Chemistry of the Cereals. III. By William Jago, F.C.S.	93
Editorial Gossip	94
Correspondence	94
Our Mathematical Column	95
Our Chess Column	96

SPECIAL NOTICES.

Part XXI. (July, 1883), just ready, price 10d., post-free, 1s. 1d.

Volume III., comprising the numbers published from January to June, 1883, just ready, price 7s. 6d.

The Title Page and Index to Volume III. is now ready, price 2d., post-free, 2½d.

Binding Cases for Volume III., price 2s. each. Including carriage per Parcels Post to any address in the United Kingdom, 2s. 3d. Subscribers' numbers bound (including Title, Index, and Case) for 3s. each.

P. O. Orders and cheques should be made payable to the Publishers, Messrs. Wyman & Sons, London, at the High Holborn District Post-office.

Agent for America—C. S. Carter, American Literary Bureau, Tribune Buildings, New York, to whom subscriptions can be forwarded.

TERMS OF SUBSCRIPTION.

The terms of Annual Subscription to the weekly numbers of Knowledge are as follows:—

	s.	d.
To any address in the United Kingdom	9	10
To the Continent, Australia, New Zealand, South Africa & Canada	13	0
To the United States of America	$3.25. or 13	0
To the East Indies, China, &c. (*vid* Brindisi)	16	2

All subscriptions are payable in advance.

OFFICE : 74-76, GREAT QUEEN STREET, LONDON, W.C.